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Levrero, Enrico Sergio and Deleidi, Matteo

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# The causal relationship between short- and long-term interest rates: an empirical assessment of the United States

Matteo Deleidi and Enrico Sergio Levrero<sup>1</sup>

## Abstract

This paper addresses one of the central aspects of the transmission mechanism of monetary policy, namely the ability of central banks to affect the structure of interest rates. To shed light on this issue, we assess the causal relationship between short- and long-term interest rates, that is, the Effective Federal Funds Rate (*FF*), the Moody's Seasoned Aaa Corporate Bond Yield (*AAA*), and the 10-Year Treasury Constant Maturity Rate (*GB10Y*). We apply Structural Vector Autoregressive (SVAR) models to monthly data provided by the Federal Reserve Economic Data (FRED). Our findings – estimated for the 1954-2018 period – outline an asymmetry in the relationship between short- and long-term interest rates. In particular, although we found a bidirectional relationship when the 10-year treasury bond *GB10Y* was included as the long-run rate, a unidirectional relationship that moves from short- to long-term interest rates is estimated when the interest rate on corporate bonds ranked AAA is taken into consideration. Furthermore, the conclusions drawn by the impulse response functions (IRFs) are confirmed and strengthened by the Forecast Error Variance Decomposition (FEVD) which shows that monetary policy is able to permanently affect long-term interest rates over a long temporal horizon, i.e., not only in the short run but also in the long run. In this way, following the Keynesian tradition, long-term interest rates appear to be strongly influenced by the central bank. Finally, despite the fact that the Federal Fund rate (*FF*) is weakly affected by long-term interest rate shocks, the estimated FEVD shows that *FF* is mainly determined by its own shock allowing us to assume that the central bank has a certain degree of freedom in setting the levels of short-run interest rates.

**Keywords:** Monetary policy, short- and long-term interest rates, yield curve, SVAR analysis

**JEL Code:** B26; E11; E43; E52

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# 1. Introduction

Several issues are still open regarding the relationship between short- and long-term interest rates. One concerns the elements that shape the structure of interest rates – in particular, the weight and variability of liquidity and risk premiums. Another issue regards the ability of central banks to affect long-term interest rates and whether their action has only a temporary or also a permanent effect. Since in practice, central banks have mainly operated within the short-run segments of bond and credit markets – at least until the recent financial crisis of 2007 – this issue is usually addressed by analysing the relationship between the short-term *policy* interest rate and the long-term interest rates on public and private bonds. This is crucial for the effectiveness of monetary policy because the components of aggregate demand – especially, private investments – are recognized to be sensitive mainly to long-term interest rates. It is also relevant when discussing whether monetary policy can affect income distribution. Only in the case of a permanent causal relationship going from the policy interest rate to bond rates – or more generally, only if central banks are able to control the structure of interest rates – an alternative theory of distribution can be advanced in which the decisions of monetary authorities on the interest rate regime have an effect on the rate of profits (cf. in this respect, Panico, 1987; Pivetti, 1991; Sraffa, 1960).

The current paper aims to estimate precisely the causal relationship between short- and long-term interest rates in both a short and long temporal horizon. Sections 2 and 3 provide a brief summary of the theoretical and empirical literature on the subject, whereas Section 4 describes the data and method used for our estimations. In particular, we consider for the United States monthly data provided by the Federal Reserve Economic Data (FRED) for the 1954-2018 period and introduce two main innovations: (i) we use Structural Vector Autoregressive (SVAR) models to test the relationship between the Effective Federal Funds Rate (FF), the Moody's Seasoned Aaa Corporate Bond Yield (AAA), and the 10-Year Treasury Constant Maturity Rate (GB10y); and (ii), we compare the potential different effect caused by monetary policy on private (AAA) and public bonds (GB10y). Our main findings are described in Sections 5 and 6. Here the results show that monetary policy is able to permanently affect long-term interest rates over a long-time horizon, i.e., not only in the short run but also in the long run. Moreover, despite the fact that the Federal Fund rate (FF) is also affected by a long-term interest rate shock (*GB10Y*), the estimated Forecast Error Variance Decomposition (FEVD) points out that *FF* is mainly determined by its own shock allowing us to assume that the central bank has a certain degree of freedom in setting the level of short-term interest rates. This may

be relevant in light of the recent ‘secular stagnation theory’ according to which the natural/neutral long-term rate of interest would be stemmed from real factors, namely the interaction between the supply of saving and demand for investment. In line with the Keynesian tradition, our findings show that monetary policy is able to produce permanent and significant effects on long-term interest rates by thus showing that interest rates should be conceived as monetary-determined variables rather than real ones.

## 2. The theory of interest rates structure

In a neoclassical perspective, capital arbitrage will adapt the real rate of interest to the expected capital profitability determined by “productivity and thrift”, at least in the long run (cf. Wicksell, 1898 and 1901; Hayek, 1930; Robertson, 1940). In some cases, when the Ricardian equivalence is rejected, this rate is also seen to be influenced by the net borrowing of public sector due to its “absorption” of private savings (cf. e.g. Caporale and Williams, 2002; Correia-Nunes and Stomitsiotis, 1999; Howe and Pigott, 1991; Ireland, 1996; Merha, 1996; Reinhart and Sack, 2000; Gruber and Kamin, 2012).<sup>2</sup>

In the case of real and financial investments of different lengths, the non-arbitrage condition is extended to equalize the expected returns from short- and long-term investment strategies. The long-term interest rate is thus seen to be approximately equal to an average of the expected spot short-term real interest rates within the time horizon taken into consideration (cf. Hicks, 1946: 145. Cf. also Fisher, 1930; Lutz, 1940). These in turn will be shaped by the *long run* expectations on the perceived levels of the “neutral” interest rate, namely the rate that is consistent with the long run growth rate (cf. Estrella and Mishkin, 1996; Bauer and Rudebusch, 2016).<sup>3</sup> The result is a *long run* real yield curve which will be flat in a stationary economy but may have a different shape if changes over time in the determinants of the natural rate of interest – namely, in households’ preferences, endowments and technical knowledge – are expected.<sup>4</sup> The same applies to the long-run structure of *nominal* interest rates which is

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<sup>2</sup> It is also argued that a country-specific default risk depending on the level of its public debt-income ratio will exist. However, the case of Japan shows us that other factors - among which, the central bank’s behaviour - are relevant in determining whether Government bonds are viewed as risky by the market. Moreover, the cases of Germany and the United States during the recent economic crises underline that portfolio effects may lead to a higher demand for public bonds and therefore to lower interest rates even if an increase in public debt occurs - and even when, as in the case of the United States, its initial ratio relative to the gross domestic product is already high compared with other countries.

<sup>3</sup>Typically, the natural or neutral interest rate is the one corresponding to potential output. See Levrero (2019).

<sup>4</sup> In the first case, the series of interest rates would be stationary, whereas in the second case, they oscillate around a moving average.

obtained by adding – as an element that shapes the yield curve – the *long-run* expected rate of inflation according to the Fisher effect (cf. Fisher, 1930).

However, unless a condition of perfect foresight and confidence is assumed (cf. Conard, 1966), even in a neoclassical perspective, the shape of the *long-run* yield curve is conceived as being influenced by the investors' perception of risk and the liquidity preference, namely the preference of borrowers for long-term loans and of lenders for short-term loans (cf. Hicks, 1946: 146-147).<sup>5</sup> Hence the interest rates structure is modified by adding a term premium to the one stemming from the expectation theory which increases with the lengthening of bond maturities (cf. Campbell et al., 1997; Shiller, 1990). Even if the expected short rates are unchanged, the long-term interest rate should in fact be higher than the rate on shorter term investments to induce investors to subscribe a forward contract. Therefore - in the presence of liquidity and risk premiums - the forward short-term interest rate will exceed the expected short-term interest rate to the extent of these premiums.<sup>6</sup> Only when the short spot interest rates are expected to fall, "the forward rates can lie below the current rate" and therefore the long-term interest rates can be lower than the current short-term rates (Hicks, 1946: 147).<sup>7</sup> A similar conclusion is achieved by the theory of preferred habits (cf. Modigliani and Sutch, 1966; Modigliani and Shiller, 1973) according to which the term premium will be higher the higher market segmentation is and therefore the lower the degree of substitutability between assets of different length and kind.<sup>8</sup> The nominal term structure would in fact be determined in this case by: (i) the expected future short term interest rates, (ii) the expectations on future changes in the price level, and (iii) risk premiums<sup>9</sup> which are not wiped out by the arbitrage activity due

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<sup>5</sup> As observed by Hicks (1946: 146-47), "if no extra return is offered for long lending most people (and institutions) would prefer to lend short, at least in the sense that they would prefer to hold their money in deposit in some way or other". Of course, this preference for liquidity applies even in the case of a unique bond due to the perspective of a change in its price. Yet, it will be higher for bonds of longer maturity also because an increase in the interest rate would lead to a greater fall in their value (cf. Campbell, 1995). More generally, the lenders will face a lower risk by shortening the loan period.

<sup>6</sup> We refer here to the interest rate of the monetary standard. The own rate of interest of each commodity may differ from it when the relative prices of the commodities change over time, namely it will be equal to the rate of the standard minus the "contango" (that is, the percentage change of the forward price of the commodity relative to its spot price). As outlined by Hicks, the "monetary" rate may also be "complex" due to a liquidity premium and default risk of the borrower.

<sup>7</sup> According to Taylor (1992), it explains the higher volatility of long-term interest rates compared with the expectation theory. As stressed by Shiller (1979) and Campbell and Shiller (1987, 1991), this means that the forward rates cannot be predictors of future spot rates (cf. also below, note 9).

<sup>8</sup> This degree of substitution is higher between assets with closer maturities.

<sup>9</sup> Nevertheless, the difference in the yield of a n-period security from that provided by the expectation theory can be positive or negative. It will depend on what is needed to bring agents with different preferred habits into the market of a specific bond when an unbalance occurs between the funds supplied by the lenders and those demanded by the borrowers. Risk premiums could be negative if a preference for income certainty (as in the case of institutional investors) prevails, or when there is a preference for risk. Risk premiums, however, are usually assumed as increasing along the yield curve (cf. Conard, 1966; Kessel, 1995).

to operating costs, reluctance to go beyond some over-all commitment on specific assets and so on.

In short – irrespective of the way in which expectations on short-term interest rates and inflation are formed – the relation will hold that

$$(1 + R_n)^n = (1 + r_1)(1 + r_2) \dots (1 + r_n) + \sigma_n \quad (1)$$

where  $R_n$  is the *real* rate of interest of a n-period asset,  $r_t$  are the expected spot short interest rates for time  $t = 1, \dots, n$ , and  $\sigma_n$  is the term premium associated to a n-period asset. The corresponding nominal interest rate will be approximately equal to  $R_n$  plus the expected average inflation rate in the time horizon taken into consideration when considering that  $(1 + r_t)(1 + \pi_t^a) = (1 + i_t)$  where  $i_t$  is the nominal interest rate for time  $t$ .

In this framework, an influence of monetary policy on the interest rate term structure is admitted only in the short run. The *short run* yield curve may differ from the one which will prevail in the long run due to changes in the risk premiums ( $\sigma_n$  in equation 1) during the cycle (cf. Orphanides and Wei, 2010), errors in expectations, the interventions of the central bank in the credit and bond markets setting the interest rate at a level which differs from the natural one, and the expectations regarding the future stance of monetary policy and business cycle conditions. It is a difference that may be fuelled by extrapolative or adaptive expectations on future short-term interest rates and price inflation as in Meiselman (1962) and Modigliani and Sucht (1973),<sup>10</sup> as well as by some inelasticity of the *expected* interest rates as needed by the theory of liquidity preference. Moreover, it is influenced by the coherence of monetary policy (Haldane, 1999) because the expectations on future short rates take into account the reaction function and policy rules of central banks, as well as their credibility. For instance, the yield curve will be different according to the credibility of the action of monetary authorities against inflation and therefore the likelihood ascribed to a further tightening or future easing of monetary policy.

This view – that is shared by the modern theory of central banking (cf. Woodford, 2003) according to which monetary authorities set the short-term interest rates and may have an

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<sup>10</sup> Fisher, on the other hand, ascribed the possibility of discrepancy between the market and natural interest rate precisely to adaptive price expectations. However, the nominal interest rates do not necessarily increase when the expected inflation rate increases irrespective of the way in which expectations are formed (cf. Tobin, 1965), nor do they necessarily change in response to actual inflation unless as the result of the central bank's reaction to a higher inflation rate. Cf. in this regard, Tymoigne (2006), who also analyses Keynes's criticism of the Fisher effect due to the absence of perfect foresight. Cf. also on empirical grounds, Caporale and Williams (2002) and Lavoie and Seccareccia (2004: 175).

influence on the *short-run* yield curve<sup>11</sup> – has similarities with Keynes’s approach and is also advanced by post-Keynesian economists (cf. e.g., Wray, 2003: 212). For Keynes, in fact, the monetary authorities can easily control the short-term interest rates and have an influence on the long-term interest rates (cf. Keynes, 1930: 353)<sup>12</sup> unless the *current* short-term interest rate “has fallen to a level which, on the basis of past experience and present expectations of *future* monetary policy, is considered ‘unsafe’ by representative opinion” (Keynes, 1936: 202-3; Keynes’ emphasis). Moreover, Keynes also points out that only a coherent monetary policy can affect the interest rate structure. In fact:

“a monetary policy which strikes public opinion as being experimental in character or easily liable to change may fail in its objective of greatly reducing the long-term rate of interest [...]” (Keynes, 1936, Ch. 15, 203).

Finally, not only Keynes emphasizes that the interest rates on loans of different length are influenced by risk premiums due to moral hazard, an insufficient yield security, “the risk and trouble” to make a productive investment. He also stresses that during a cyclical boom the risks accounted by lenders and borrowers become “imprudently low” (Keynes, 1936: 145) and that – in a market economy – there is an inherent tendency to speculative bubbles fuelled by expectations of capital gains. Incidentally, this would give us an explanation of the volatility of the long-term interest rates (cf. McCulloch and Shiller, 1987; and Engle et al., 1987)<sup>13</sup> which would differ from that in terms of time varying risk premiums as determined in the capital asset price model of Lucas (1978).<sup>14</sup>

However, the Keynesian approach to the interest rate term structure differs from that which prevails nowadays when following a neoclassical perspective mainly for three reasons. First, it emphasizes that in a capitalist economy there are institutional and social limits to the arbitrage activity between the present and the future. Second, a limited impact on the nominal interest rates is ascribed to the Fisher effect. According to Keynes, if a higher inflation rate is not forecast, it cannot affect the current decisions of lenders and borrowers, and when prices rise it will be too late for money holders to put inflation up by means of a change in the nominal interest rate. Moreover, even when price inflation is forecast, the arbitrage activity would

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<sup>11</sup> On central banks setting the interest rate, cf. Bindseil (2004) and Fullwiler (2008).

<sup>12</sup> Keynes, in this respect, refers to Reifer (1930). Cf. Keynes (1930: 359-362; and 1936: 152-53).

<sup>13</sup> According to Kessel, it would also stem from the fact that the short-term bonds are closer substitutes of money and so, when the interest rate rises, the opportunity cost to hold short term bonds compared with long term bonds also increases, which means a higher liquidity premium for the latter.

<sup>14</sup>In Lucas (1978), the long term real interest rates are estimated indirectly by means of a constrained intertemporal utility maximization in a world of uncertainty on nominal prices and incomes. Cf. also Hirshleifer (1970).

mainly regard money and real goods<sup>15</sup> and there might be a limited incentive to arbitrage because an increase in the nominal interest rate would lead to a fall in the value of assets and be to some extent counterproductive (Kahn, 1954).<sup>16</sup>

More importantly, for Keynes the long run interest rate does not stem from any underlying long-term market forces preventing central banks from controlling the long-run rate of interest. For Keynes, central banks operate on short-term interest rates only due to institutional settings that lead them in practice “to concentrate upon short-term debts and to leave the price of long-term debts to be influenced by belated and imperfect reactions from the price of short-term debts.”<sup>17</sup> Yet, Keynes maintains, “there is no need to do so” (cf. Keynes, 1936: 206), namely market operations should not be limited to the purchase of very short-dated securities. Moreover, he stresses that open market operations can “change expectations concerning the future policy of the central bank or of the government” (cf. Keynes, 1936: 197) affecting, in this way, the interest rates term structure in the short as well as the long run. Thus, according to Keynes, the long-run interest rate may for decades be at a level that is “chronically too high for full employment” and it is “a highly conventional” phenomenon because

“its actual value is largely governed by the prevailing view as to what its value is expected to be. Any level of interest which is accepted with sufficient conviction as likely to be durable will be durable; subject, of course, in a changing society to fluctuations for all kinds of reasons around the expected normal” (Keynes, 1936: 203).<sup>18</sup>

This idea that central banks may control the long-run interest rates by shaping the short-run rates and their expected levels is also shared by the more recent post-Keynesian literature (see among others, Moore, 1988; Wray, 1992; Godley, 1999), according to which portfolio choices – by changing the desired proportions of different assets<sup>19</sup> – will adapt the prices of

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<sup>15</sup>In fact bonds, like money, do not usually protect the lenders from inflation.

<sup>16</sup>The idea of Cottrell (1994) that an increase in the nominal rate would nevertheless occur due to an increase in the level of income stemming from a higher marginal efficiency of capital that would be the consequence of a higher expected inflation rate does not consider that money is endogenous and the scant reactivity of investment to the interest rate.

<sup>17</sup>A recent example of this institutional setting is provided by the following quotation: “Before the global financial crisis, the Federal Reserve used OMOs to adjust the supply of reserve balances so as to keep the federal funds rate - the interest rate at which depository institutions lend reserve balances to other depository institutions overnight - around the target established by the FOMC.” <https://www.federalreserve.gov/monetarypolicy/openmarket.htm>.

<sup>18</sup>For a case of a long-term interest rate that is set on average at a level that is higher than the “neutral” rate, Keynes refers to the experience before the First World War when the Bank of England kept the interest rates at a level that was too high for full employment in order to favour the financial interests of the City of London. Another example of a conventional and stable long-term interest rate controlled by the central bank is, for Keynes, after the abandoning of the gold standard (cf. Keynes, 1936: 204).

<sup>19</sup>This differs from Tobin (1969) where asset supplies are given and market arbitrage determines the structure of interest rates.



long-term bonds to those of short-term bonds influenced by the central bank. However, it does not mean that central banks do not encounter obstacles to their actions aimed at controlling the long-term interest rates, especially in the short run (cf. Pollin, 1996). These obstacles may arise from liquidity preference becoming virtually absolute, abnormal circumstances, a currency crisis, changes in the risk premiums and profit margins of the bank system. Nor does it mean that monetary policy rate is set in a vacuum independent of distributive and external constraints, especially in the case of a small country facing free cross-border capital flows.<sup>20</sup> It means, however, that central banks – especially for a country with a leading role in the financial markets – may have the instruments to face expectations of capital losses and the power to set – *on average* – the long term interest rate at a desired level (cf. also Lavoie and Seccareccia, 2004). Besides changing the policy rate, monetary authorities can achieve their objectives by operating in specific market segments in order to influence the spread between short-and long-term interest rates, intervening in the exchange foreign markets and varying the collaterals admitted to financing the bank system (cf. Levrero, 2019). The experiences of the Federal Reserve and the European Central Bank in the last decade provide several insights in this respect.

Unlike what is stated in any model centred on a tendency of the market interest rate to a natural rate, Keynes's statement that central banks may set on average the long-term interest rate also means that their action can affect long-run capital profitability. According to Keynes, this would pass through a change in the amount of investments insofar as the marginal efficiency of capital differs from the monetary interest rate.<sup>21</sup> A more direct cost-adjustment mechanism has been advanced, however. Taking the money wages, the normal profits of enterprise and the methods of production as given, under the pressure of competition the price level will vary in the same direction as the long-term interest rate on riskless bonds<sup>22</sup> because this rate enters into the *normal* costs of production of the commodities since it is the opportunity

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<sup>20</sup> For an analysis of the influence of the expected exchange rates on the interest rates cf. Lavoie (2000) who criticize the power purchasing parity theorem and also a necessary tendency to a real interest parity less than a risk premium determined by the amount of foreign indebtedness. According to Lavoie (2000), the forward exchange rate is institutionally set at a value equal to the current exchange rate plus the difference between the domestic interest rate and the rate prevailing at the international level. Central banks may manipulate the difference between spot and forward exchange rates with interventions in these markets.

<sup>21</sup> The money interest rate is according to Keynes the greatest own interest rate that the marginal efficiency of capital assets must attain if they are to be newly produced. It has, according to Keynes, the greatest liquidity premium, zero carrying costs, zero nominal appreciation or depreciation and zero productive return. More generally, according to Keynes, it is the asset whose own interest rate falls more slowly that eventually knocks out the profitable production of each of the other assets unless an appreciation of prices occurs.

<sup>22</sup> Note that this adjustment through the "cost channel" also helps to explain the scant reactivity of investments to the rate of interest because its changes would determine a change in the same direction as capital profitability.

cost of capital irrespective of the form of firm financing. Therefore, its change will lead to a change in the ratio of prices relative to money wages and thus in capital profitability (cf. Pivetti, 1991).

While this idea of a “monetary theory of distribution” differs from that of a natural rate of interest set by “productivity and thrift” as in Wicksell, it also differs from any approach in which the rate of profits depends on real factors. For instance, in Marx, the rate of profit is determined by the real wage rate and the technical conditions of production whereas in post-Keynesian models, the rate of profits is determined by the rate of capital accumulation according to the Cambridge equation (cf. Kaldor, 1956).<sup>23</sup> Only in this latter case, however, the long-run interest rate will be determined on average by the rate of profits (cf. Nell, 1999).<sup>24</sup> In Marx, the rate of profit would only shape the upper limit of the rate of interest – at least from a certain point of capitalist development when usury capital lost relevance – and the division of the profit rate between the interest rate and the normal profit of enterprise would depend on the power relations between financial and industrial capital which can change in the course of capitalist development. (cf. Panico, 1987)

### **3. The estimates on the relationships between short- and long-term interest rates**

In order to discuss the relationship between interest rates on assets with different lengths and risks, we can focus on four rates, namely the nominal policy interest rate  $i_c$ , the nominal interest rate on a short-term public bond  $i_{sg}$ , the rate  $i_{lg}$  on a long-term public bond which is riskless but has a lower degree of liquidity compared with assets of shorter length, and finally the nominal rate of interest on long-term *private* bonds  $i_{lf}$  that also includes a risk premium which is related to productive investment<sup>25</sup> but is lower than that embodied in the yields of the stock market. Due to the arbitrage activity of households and firms, the other rates should move in

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<sup>23</sup>As known, assuming for the sake of simplicity that workers’ propensity to save is zero, the equality between savings per unit of capital  $s_c r$  (where  $s_c$  is the propensity to save of capitalist, and  $r$  the rate of profits) and the rate of accumulation  $\frac{I}{K}$ , namely  $\frac{I}{K} = s_c r$ , would imply that  $r$  is determined by the rate of capital accumulation. For a criticism of this theory of distribution, cf. Garegnani (1992).

<sup>24</sup> Asset returns in the stock market are related to firm profits and if the profit rate rises, asset owners will buy stocks and sell financial assets (bonds), that is, capital arbitrage will decrease the price of bonds and increase the rate of interest on long-term bonds.

<sup>25</sup> It can be affected by some measure of credit worthiness for business enterprises.

the same direction unless changes in expectations and risk premiums occur that affect the shape of the nominal yield curve.<sup>26</sup> We have

$$i_c = \bar{i} \quad (2)$$

$$i_{sg} = i_c + t_{sg} \quad (3)$$

$$i_{lg} = i_{sg} + t_{lg} \quad (4)$$

$$i_{lf} = i_{lg} + \sigma_f \quad (5)$$

where usually  $i_c < i_{sg} < i_{lg} < i_{lf}$ ;  $t_{sg}$  is the term premium for the short-term bond which is affected by expectations on future monetary policies and by a liquidity premium, as well as, if relevant, by the expectations on future price inflation;  $t_{lg}$  is the *additional* term premium that stems from the same factors mentioned above when considering the *additional* length of time taken into consideration for long-term government bonds;  $\sigma_f$  is the risk premium for a private long-term bond compared to the interest rate on long-term public bonds.

With these premises, the issues to be analysed are if and to what extent monetary authorities affect the structure of interest rates through their policy instruments, and whether the causal relation between short- and long-term interest rates is one-directional and differs in short and long temporal horizons.

Looking at the experience of the United States, a change in the short-term interest rate is usually deemed to affect the long-run rates but with a different intensity (cf. Estrella and Mishkin, 1997; Cock and Hahn, 1989). As a broad rule, for Poole (2005) and Rudebusch et al. (2006), in the period 1984-2005, a 1% point increase in the Federal Funds rate  $FF$  would lead to an increase of about 30 basis points in the 10-year bond rate. According to Atesoglu (2005), typically the  $FF$  and the bond rates move together (see also Akran and Li, 2016),<sup>27</sup> but there is less than complete pass-through from the former to the long-run interest rates (specifically, on 10-year and 30-year Treasury bonds, and on AAA bonds). Moreover, the effect is in the short run lower than in the long run when the cointegration coefficient is approximately equal to 0.6. Finally, Akhtar (1995) estimates that the effect on the long-term interest rate of a percentage change of 1 per cent in the short interest rate oscillates between 22 and 60 basis-points.

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<sup>26</sup> For instance, the bank deposit rate is affected by the interest rate on short-term public bonds because they are close substitutes for households, whereas the rate of interest on short-run bank loans is influenced by the overnight interest rate set in the interbank market as well as by the rate on short-term bonds that the banks can buy. Similarly, the rate on long-run bank loans and on long-run bonds issued by private firms are affected by the long-run interest rates on riskless assets and in turn affect the yields in the stock market (cf. Godley, 1999).

<sup>27</sup> Akran and Li (2016) also argue that the short-term rate falls after a depression and rises before a recession so that a negatively sloped yield curve would reveal an onset recession in the United States.

Other contributions, however, reject a clear response and co-movement of the long-term interest rates after a change in the policy rate. For the sub-periods 1983-1990, 1991-2000 and 2001-2007, Thornton (2012) calculates a decreasing response to a change in  $FF$ , with even a slight negative correlation in the last period when considering private AAA bonds.<sup>28</sup> Akhtar (1995) and Mehra (1996) point out that the effect would hold only in the short run because in the long run the monetary policy is neutral and the *real* interest rate is determined by the rate of return on capital (cf. also Cagan, 1972). Therefore, if in the long run the nominal bond rates move together with the policy rate, it is only because the long-term interest rates adjust to the expected inflation rate and at the same time, the Federal Reserve adjusts the policy rate to the inflation rate.<sup>29</sup> Moreover, if in the short run a tighter monetary policy can lead to higher interest rates, afterwards, lower short and long-term nominal interest rates may occur due to lower expected inflation rates.

It is also stated that, in the short run, the relation would be unstable and fail to support the expectation hypothesis (cf. Grishchenko et al., 2015; McCallum, 2005) due to variable term premiums which are not under the control of the monetary authorities – especially in recent decades after deregulation of the financial markets (cf. Comert, 2012; Pollin, 2006).<sup>30</sup> Two examples are usually put forward in this respect. The first refers to the years 1994-1995 when a slight increase in the short-term interest rates was accompanied initially by a strong increase in the long-term interest rates and afterwards by a decline of the latter. The second example refers to Greenspan's conundrum after the fall in the  $FF$  rate from 6.7 to 1 per cent in the years 2000-2004, namely the fact that its subsequent rise in the years 2004-2006 to 5.4 per cent was accompanied by a slight *fall* in the interest rate on 10-year government bonds and on corporate BAA bonds.

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<sup>28</sup> Similarly, Comert (2012) points out that between 2000 and 2010, a “decoupling” between short- and long-term interest rates occurs. A scant effect on the long-term interest rates of a change in the short-term rates is advanced on the other hand by Roley and Sellon (1995) who ascribe it to the influence of expectations on future short-term interest rates. Cf. also Cock and Hahn (1989) and Radecki and Reinhart (1994) according to whom the long-term interest rates would only rise by 4 to 10 basis points in response to an increase of 100 basis points in the policy rate.

<sup>29</sup> For Mehra (1996) “there is no other source of long run interaction between the bond rate and the funds rate” because the expected long *real* rate is mean stationary and in the long run is unrelated to the level of the federal funds rate. Therefore, the monetary policy would lower the bond rate only by lowering the trend rate of inflation. On the contrary, in the short run, the rise in  $FF$  may increase the expected *real* short rate while lowering at the same time the expected inflation rate.

<sup>30</sup> According to Pollin (2008) in the period 1973-2008, the mean spread between short- and long-term interest rates could not be used to forecast the latter due to a high standard deviation. Therefore, while expectations on monetary policy would be an element shaping the long-term interest rates as suggested by Moore (1988: 206), other factors such as liquidity preference, preferred habits and uncertainty should be taken into consideration. It is worth noting, however, that for 30 years mortgages and BAA bonds, Pollin shows a spread with respect to  $FF$  equal to 2.69 and 3.03 respectively, and that in these cases, the standard deviation is only 0.6% larger than the mean.

The first case has usually been interpreted as the result of shifts in the yield curve due initially to an expectation of incipient inflation and thus of further increases in the short interest rates (cf. Campbell, 1995; Rudebusch et al., 2006).<sup>31</sup> A variety of explanations has been advanced, however, for the years 2004-2005. Reference has been made to the effect of foreign intervention of Bank of Japan in the bond markets after the Asian crisis of the end of the 1990s (Bernanke et al., 2004; Caballero, 2006; Warnock and Warnock, 2005)<sup>32</sup> and to the expectation of a slow departure from the previous expansionary stance of monetary policy (Poole, 2005) and thus of interest rates remaining below the natural interest rate (cf. Gruber and Kamin, 2012; Idier, Jarret and Loubens, 2007; Rudebusch, Swanson and Wu, 2006). Mostly, Greenspan's conundrum has been explained by a saving glut due to global imbalances (Bernanke, 2005; 2011) and by lower risk premiums associated to regulatory changes on asset/liability management, to a shift in private portfolio preferences towards sovereign bonds, and to a lower macroeconomic volatility and lower uncertainty over monetary policy (Rudebusch et al., 2006).

The power of central banks to control *over time* the structure of interest rates by affecting market expectations emerged again, however, during the years following the recent crisis of 2007-2008 (cf. Gagnon et al., 2011; Christensen and Rudebusch, 2012). Nevertheless, econometric analyses based on Granger causality<sup>33</sup> do not show clear-cut results regarding the causal direction between short- and long-term interest rates in both a short and long temporal horizon. Lavoie and Seccareccia (2004) found a one-way Granger causality from corporate bond rates to the yields of stock market for quarterly data, but a two-way Granger causality in the case of annual data. Pollin (2008) excluded any clear one-way line of causation running from *FF* to the market rates for the years 1973-2008, while Atesoglu (2005), using a VECM analysis, found a unidirectional causality in the years 1987-2002 that runs from the federal funds rate to the AAA corporate bond yield. However, using the same method, Tymoigne (2006) showed for the years 1914-2004 long-term bidirectional causality between these rates and short-term causality going from the market rates to *FF*.<sup>34</sup>

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<sup>31</sup> Following Furher (1995), a change in the parameters of the reaction function of the central bank has also been considered.

<sup>32</sup> The influence of international capital movements has also led to the argument that there is a *global* yield curve and that within each country the correlation is stronger for rates of close maturities than for rates of distant maturities (cf. Moon and Perion, 2007; Diebold et al, 2008).

<sup>33</sup> The long-term interest rates are said to be Granger-caused by the Federal Funds rate if the latter helps in the prediction of the current values of long-term rates – that is, if the coefficients on the lagged values of the Federal Funds rate are statistically significant in explaining the current long-term interest rates.

<sup>34</sup> Causality would hold only from the *expected* Federal Funds rates to the market rates, but with weak intensity.

Finally, Rahimi, Chu and Lavoie (2016; 2017) found time-varying linear and non-linear Granger causality relationships between  $FF$  and the 10-year government bond. According to them, as the *linear* causality effect from  $FF$  to the 10-year bond rate increases with the passing of time, there is a significant bidirectional Granger causality relationship during all time periods when the linear and non-linear causality tests results are combined, with the impact of the long-term interest rate on  $FF$  appearing to be more systematic. Whereas this last conclusion would provide support to Pollin's (2008) claims regarding bidirectional Granger causality, they show, in disagreement with Pollin, however, that there is significant linear Granger causality from  $FF$  to the 10-year bond rate during many of the recent time periods, ascribing the result to the Federal Reserve targeted interest rate which was publicly announced in 1994.

### 3. Data and methods

In order to assess if the monetary authorities have the power to affect the interest rate term structure, in the rest of the paper, SVAR models will be implemented to test the causal relationship between short- and long-term interest rates, allowing us to go beyond the current state of the art (Atesoglu, 2005; Rahimi et al., 2016; 2017). To the best of our knowledge, at least within the long-lasting Keynesian tradition, this is the first attempt to use these models to analyse interest rate determination.

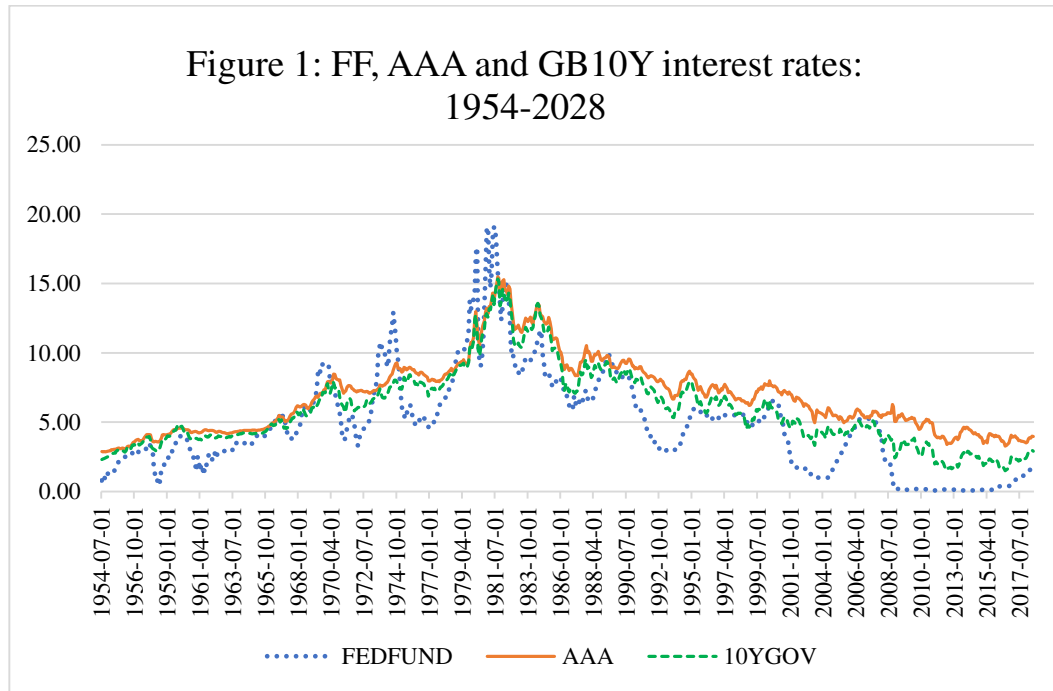
#### 3.1. Data

Our empirical analysis uses aggregate monthly data for the US provided by the Federal Reserve Economic Data (FRED). In particular, we use the Money, Banking and Finance dataset which provides data on interest rates. All of the considered variables are summarized in *Appendix 1* and a full description of data is provided below. To estimate the existing relationship between short- and long-term interest rates, Effective Federal Funds Rate ( $FF$ ), Moody's Seasoned Aaa Corporate Bond Yield ( $AAA$ ) and 10-Year Treasury Constant Maturity Rate ( $GB10Y$ ) are employed.  $FF$  is a short-term rate at which commercial banks lend reserves and liquidity to other depository institutions overnight.<sup>35</sup>  $AAA$  is a long-term interest rate, usually with maturities of 20 years and above, on corporate bond rated  $AAA$  by Moody.  $GB10Y$  is a long-

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<sup>35</sup> Yet, despite the fact that we consider  $FF$  as the short-term rate set by the central bank, FED controls  $FF$  by means of monetary policy and changes of the discount rate ( $DR$ ).  $DR$  is a short-term rate which the Federal Reserve (FED) charged to commercial banks on loans they obtained from the FED. Specifically, this is the interest rate charged on the primary credit discount window programme, namely the short-term rate applied to loans granted to sound depository institution.

term interest rate on government bonds with a maturity of 10 years. The considered time series start from July 1954 and end in June 2018 and the selected period depends on data availability. Variables are not transformed into a logarithmic form since they could be zero and assume negative values. Since  $FF$ ,  $AAA$  and  $GB10Y$  are not seasonally adjusted, an ARIMA X-11 procedure is carried out to remove seasonality. The path of considered variables is represented in *Figure 1*.



### 3.2. Models

We will detect the relationship between short-and long-term interest rates by estimating two different models:

**Model 1:**  $FF - AAA$

**Model 2:**  $FF - GB10Y$ .

In both models, we estimate the causal relationship between the short-term interest rate  $FF$  and the selected long-term interest rates  $AAA$  and  $GB10Y$ . In particular, we are interested in understanding whether the central bank is able to generate a permanent effect on the long-term interest rate over a long temporal horizon as well as whether long-term rates are able to affect the short-term interest rate. As a robustness check, both *Models 1* and *2* will be estimated on different subsamples which are calculated by dropping a selected period of time

from the starting sample, namely 1954:07–2018:06. More specifically, the subsamples range from: (i) 1954:07 to 2008:08; (ii) 1971:08 to 2018:06; (iii) 1954:07 to 1971:07 and from 1982:10 to 2018:06; (iv) 1954:07 to 1982:11 and from 1993:07 to 2018:06; (v) 1954:07 to 1993:08 and from 2008:09 to 2018:06. The identification of selected structural breakpoints depends on a periodization which is based both on alternative US monetary policy regimes and main historical economic facts. In particular, we consider August 1971, October 1979, November 1982, July 1993 and September 2008 as the main relevant turning points in US economic history. To be precise, in August 1971, Nixon declared the end of the Bretton Woods System, namely the end of dollar convertibility to gold; in October 1979, Paul Volcker announced a tight control over money supply which was gradually slackened in November 1982 and permanently ended in July 1993 (Mishkin, 2001); in September 2008, after the collapse of Lehman Brothers, the Fed launched an unconventional monetary policy (i.e. quantitative easing programme) to support financial market conditions and limit the economic slowdown (Engen *et al.*, 2015) by rapidly expanding its balance sheet (Hetzel, 2009; Blinder, 2010).

### 3.2. Methods

First, in order to arrange the data accurately, a standard unit root test is conducted to understand the order of integration of selected variables. For this purpose, the Phillips-Perron test is performed both at levels and first differences of *FF*, *AAA* and *GB10Y*. Results are reported in *Appendix 2* and show that variables are not stationary at levels but become stationary at first differences. Second, we conduct the optimal lag length of the VAR by minimizing the Akaike Information Criterion (AIC). In *Model 1*, the optimal lag is 25 and in *Model 2*, it is 23. AIC results are reported in *Appendix 3*.

However, despite the fact that considered variables are I(1) or non-stationary, a reduced-form VAR in levels estimated as a cointegration relationship between considered variables may exist. In this case, the results for the estimator of a VAR in levels imply analogous results of the corresponding vector error correction model (VECM), since the latter model can be reparametrized as a reduced-form VAR model in levels (Lütkepohl, 2005; Kilian & Lütkepohl, 2017). A reduced-form VAR(p) is represented as shown in equation (6):

$$y_t = c + \sum_{i=1}^p A_i y_{t-p} + u_t \quad (6)$$



where  $y_t$  is the  $k \times 1$  vector of considered variables,  $c$  is the constant term,  $A_i$  is the  $k \times k$  matrix of reduced-form coefficients and  $u_t$  is a  $k \times 1$  vector consisting of the error terms. In order to assess the causal relationship between selected interest rates, exogenous variations in these variables have to be identified. To do this, an identification strategy has to be imposed at equation (6) to obtain a structural model, namely a Structural VAR (SVAR). A SVAR( $p$ ) can be represented as follows in equation (7):

$$B_0 y_t = c + \sum_{i=1}^p B_i y_{t-p} + w_t \quad (7)$$

where  $B_0$  represents the matrix of contemporaneous relationships between the  $k$  variables in  $y_t$ ,  $B_i$  is the  $k \times k$  matrix of autoregressive slope coefficients, and  $w_t$  is the vector of structural shocks. The covariance matrix of structural errors is normalized:  $E(w_t w_t') = \Sigma_w = I_K$ . The estimation of the  $B_0$  (or equivalently  $B_0^{-1}$ ) matrix is implemented using the Maximum Likelihood method. This requires the imposition and identification of restrictions on the contemporaneous relationship between variables, which are typically derived from economic theory.<sup>36</sup> In this case, we impose a recursively identified model through a Cholesky decomposition where  $FF$  is ordered as first variable. The identification schemes used for Models 1 and 2 are summarized in the system in equation (8) and (9):

$$B_0 y_t = \begin{bmatrix} - & 0 \\ - & - \end{bmatrix} \begin{bmatrix} FF_t \\ AAA_t \end{bmatrix} \quad (8)$$

$$B_0 y_t = \begin{bmatrix} - & 0 \\ - & - \end{bmatrix} \begin{bmatrix} FF_t \\ GB10Y_t \end{bmatrix} \quad (9)$$

where ‘—’ indicates an unrestricted parameter and a “0” represents a zero restriction. By means of the identification strategies in the system of equations (8) and (9), we assume in the first equation of both models a completely exogenous  $FF$ . More specifically, within the monthly observation, the central bank can directly control  $FF$ , regardless of the level of the long-term interest rates. Conversely, by assuming unrestricted parameters in the second equation of (8) and (9), the short-run interest rate ( $FF$ ) can affect the level of long-run interest rates ( $AAA$  and  $GB10Y$ ). Such an identification strategy is consistent with a Quarterly Bulletin published by

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<sup>36</sup> The validity of SVAR models rests on the credibility of the identification strategy imposed on the matrix  $B_0$  (Kilian and Lütkepohl 2017).

the Bank of England according to which the central bank is able to affect a range of interest rates in the economy by controlling the short-term interest rate (McLeay et al., 2014).

Identification makes it possible to generate a structural model and detect and quantify the causal relationships between the variables of interest by estimating both an impulse response function (IRF) and the forecast error variance decompositions (FEVD) (Kilian and Lütkepohl, 2017). Thus, once restrictions are imposed and the SVAR is estimated, an IRF is calculated with standard errors estimated through the asymptotic distribution. The IRF will be reported with a two-standard error bound, namely a 95% confidence interval.<sup>37</sup> Estimates of FEVD will also be provided and it shows how much of the forecast error variance of  $y_{t+h}$  (where  $h = 0, 1, \dots, H$ ) is determined by each structural shock ( $w_t$ ) identified in our models (Kilian and Lütkepohl, 2017). This test – along with the IRF – assesses the extent to which the variability of variables considered in *Models 1* and *2* is determined by the identified structural shocks.

Finally, in order to assess the presence of a non-linear relationship between considered variables, we estimate a threshold dynamics SVAR (ThSVAR) (Balke, 2000). To do this, a threshold will be computed on the short-term interest rate *FF* by using the method of simulation implemented by Hansen (1996). Subsequently, a generalized IRF (GIRF) will be estimated to capture the feasible non-linearity relationship between short- and long-term interest rates. In particular, we are interested in detecting whether: (i) the different regimes (i.e., above or below the threshold) produce different IRFs; (ii) positive and negative changes in *FF* (within the same regime) engender a symmetrical effect on long-term rates *AAA* and *GB10Y*.

## 4. Findings

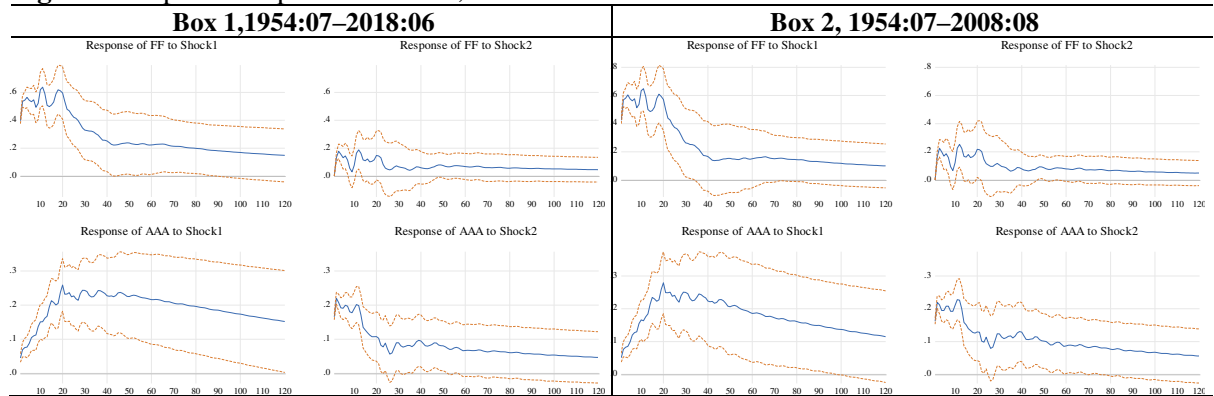
In this paragraph, we report the results of IRF and FEVD estimated for *Models 1* and *2* for the period 1954:07–2018:06 and the subsample 1954:07 to 2008:08. These findings are reported in Figures 2 to 4 where Shock 1 represents an exogenous change in the short-run interest rate (*FF*), while Shock 2 is a shock to the long-run interest rate. In *Model 1*, the variable which identifies Shock 2 is *AAA* whereas in *Model 2*, it is *GB10Y*. The results regarding the additional subsamples are discussed in the next paragraph and IRFs are reported in *Appendix 4*.

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<sup>37</sup> With regard to the choice of standard-errors bands, see Sims and Zha (1999) and Kilian and Lütkepohl (2017, p. 334)

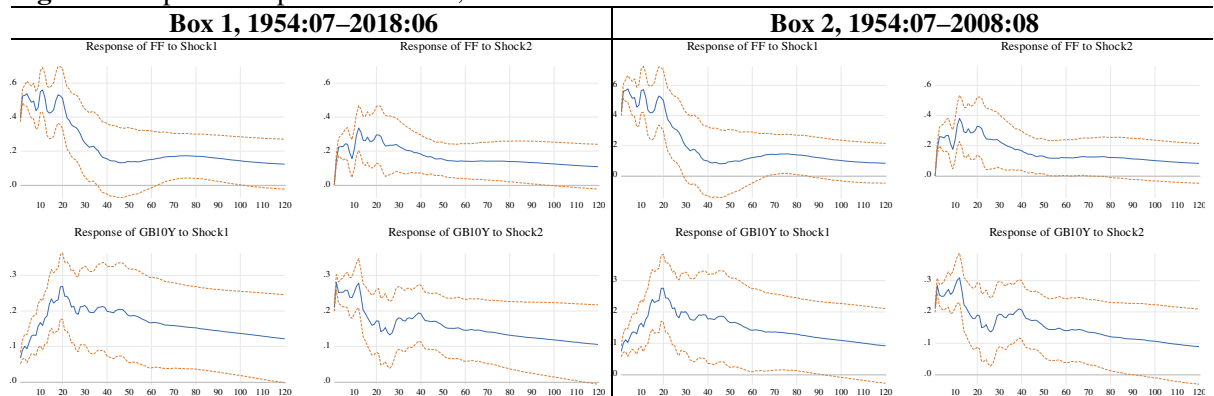
As shown in Figure 2, when we consider *Model 1* for the period 1954:07–2018:06 (Box 1) and the subsample 1954:07–2008:08 (Box 2), we can affirm that a positive shock to *FF* (Shock 1) exerts a significant, positive and permanent effect on the private long-term interest rate *AAA*. The dynamic effect estimated through an IRF produces a significant peak response after twenty months and remains significant at a longer horizon of one hundred and twenty months (*Figure 2*, Box 1). The same dynamics as the IRF occur when we consider the sub-sample 1954:07–2008:08 (*Figure 2*, Box 2) with a non-significant result of the IRF after one hundred months. Yet, despite the fact that a positive shock to private long-term rate *AAA* (Shock 2 in *Figure 2*) engenders a weak positive effect on *FF* within the first six months, the effect of Shock 2 becomes non-significant for all the remaining considered horizon. We can therefore affirm that one direction of causality that moves from the short-run interest rate to the long-run *AAA* rate exists. This unidirectional effect from short- to long-term interest rates is not confirmed when we include the 10-Year long-term interest rate on treasury bond (*GB10Y*) in *Model 2*. Indeed, when *GB10Y* is considered, a bidirectional effect is estimated.

**Figure 2.** Impulse Response Function, Model 1.



Shock 1 and Shock 2 correspond to exogenous changes in *FF* and *AAA*, respectively. Two-standard error bands corresponding to a 95% confidence interval.

**Figure 3.** Impulse Response Function, Model 2.



Shock 1 and Shock 2 correspond to exogenous changes in *FF* and *GB10Y*, respectively. Two-standard error bands corresponding to a 95% confidence interval.

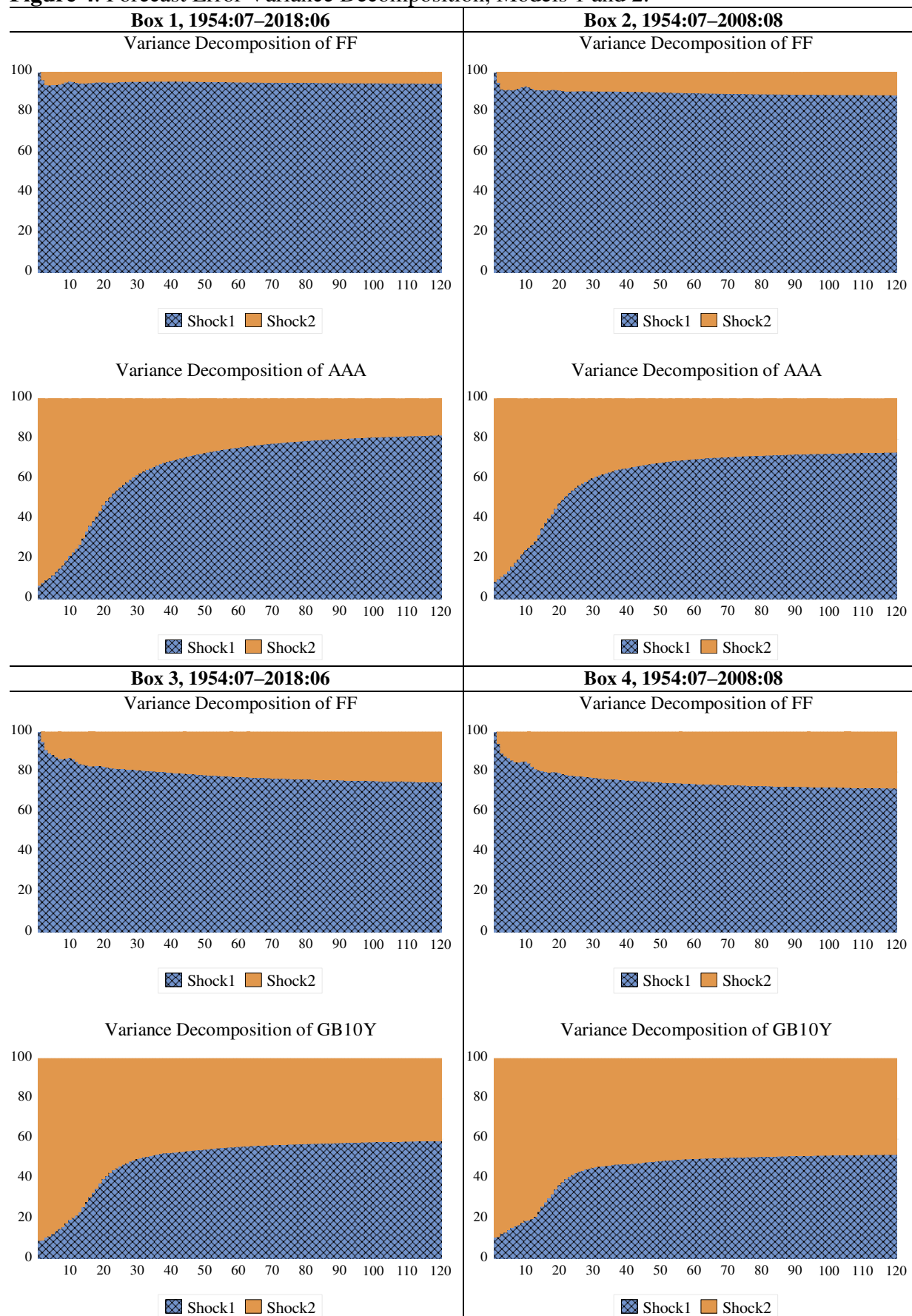
As shown in *Figure 3*, a positive shock to *FF* (Shock 1) generates a positive, permanent and long-lasting effect on *GB10Y*. In the two selected periods of time (*Figure 3*, Box 1 and Box 2), the IRF associated to shock 1 produces a significant peak response after twenty months which remains significant at a longer horizon of one hundred and twenty months. In the case of shock 2, the IRF generates a peak effect after fourteen months which remains significant at a longer horizon of one hundred (*Figure 3*, Box 1) and seventy months (*Figure 3*, Box 2).

Such results are confirmed and strengthened when forecast error variance decomposition (FEVD) is estimated for *Models 1* and 2. Findings are reported in *Figure 4*, where Boxes 1 and 2 regard FEVD estimated for *Model 1* whereas Boxes 3 and 4 are the estimations of FEVD for *Model 2*.<sup>38</sup> In the case of *Model 1*, *FF* shock (Shock 1) accounts for 95% of the FEVD of *FF* for all the considered horizon, namely one hundred and twenty months (*Figure 4*, Box 1). A similar average result of 90% for Shock 1 is estimated when a different time span is considered when studying the FEVD of *FF* (*Figure 4*, Box 2). In other words, the FEVD of *FF* is completely determined by its own shock. On the contrary, when in *Figure 4* (Box 1) we look at the FEVD of *AAA*, Shock 1 accounts for 15% in the first year, 82% after one hundred and twenty months and 66% on average. Shock 2 accounts for 34% of the FEVD of *AAA*. When a different time span is considered in Box 2, Shock 1 continues to explain most of the FEVD of *AAA*. Shock 1 accounts for 17% in the first year increasing to 73% after one hundred and twenty months. On average, Shock 1 accounts for 62% of the FEVD of *AAA*. In other words, Shock 1 (*FF* shock) explains the great extent of FEVD of the long-term interest rate *AAA*. On the contrary, Shock 2 (*AAA* shock) has a weak effect on the FEVD of *FF* rate and *AAA*. When we look at the FEVD estimated for *Model 2* (*Figure 4*, Box 3 and 4), the shock to the long-run interest rate *GB10Y* explains the FEVD of *FF* and *GB10Y* more than that estimated in the case of *Model 1*. In particular, the average estimated on one hundred and twenty months shows that 79% of the FEVD of *FF* is explained by its own shock (*Figure 4*, Box 3). Such a result is 76% when a subsample is considered (*Figure 4*, Box 4). With regard to the FEVD of *GB10Y*, a Shock to *FF* (Shock 1) accounts for 15% in the first year, 59% after one hundred and twenty months and 50% on average. When a subsample is considered (*Figure 4*, Box 4), Shock 1 explains 16% of the FEVD of *GB10Y* in the first year, 52% after one hundred and twenty months and 45% on average.

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<sup>38</sup> Tables of FEVD are available upon request.

**Figure 4.** Forecast Error Variance Decomposition, Models 1 and 2.



The findings estimated by means of the IRF and FEVD allow us to draw three main conclusions. First, an asymmetry in the relationship between short- and long-run interest rates exists. In particular, although we found a bidirectional relationship in *Model 2* when the 10-year treasury bond *GB10Y* is included as the long-run rate, a unidirectional relationship that moves from short- to long-run interest rates is estimated when the interest rate on corporate bonds ranked *AAA* is taken into consideration in *Model 1*. Second, the conclusion drawn by the IRF is confirmed and strengthened by the FEVD and shows that monetary policy is able to permanently affect long-term interest rates over a long horizon, that is to say, not only in the short run but also in the long run. In this way, following the Keynesian tradition, long-term interest rates appear to be strongly influenced and determined by the central bank. Third, despite that fact that in *Model 2* *FF* is affected by the long-term interest rate shock (Shock 2), the estimated FEVD shows that *FF* is mainly determined by its own shock allowing us to assume the central bank has a certain degree of freedom in setting the level of the short-run interest rate.

## 5. Linearity, stability and robustness

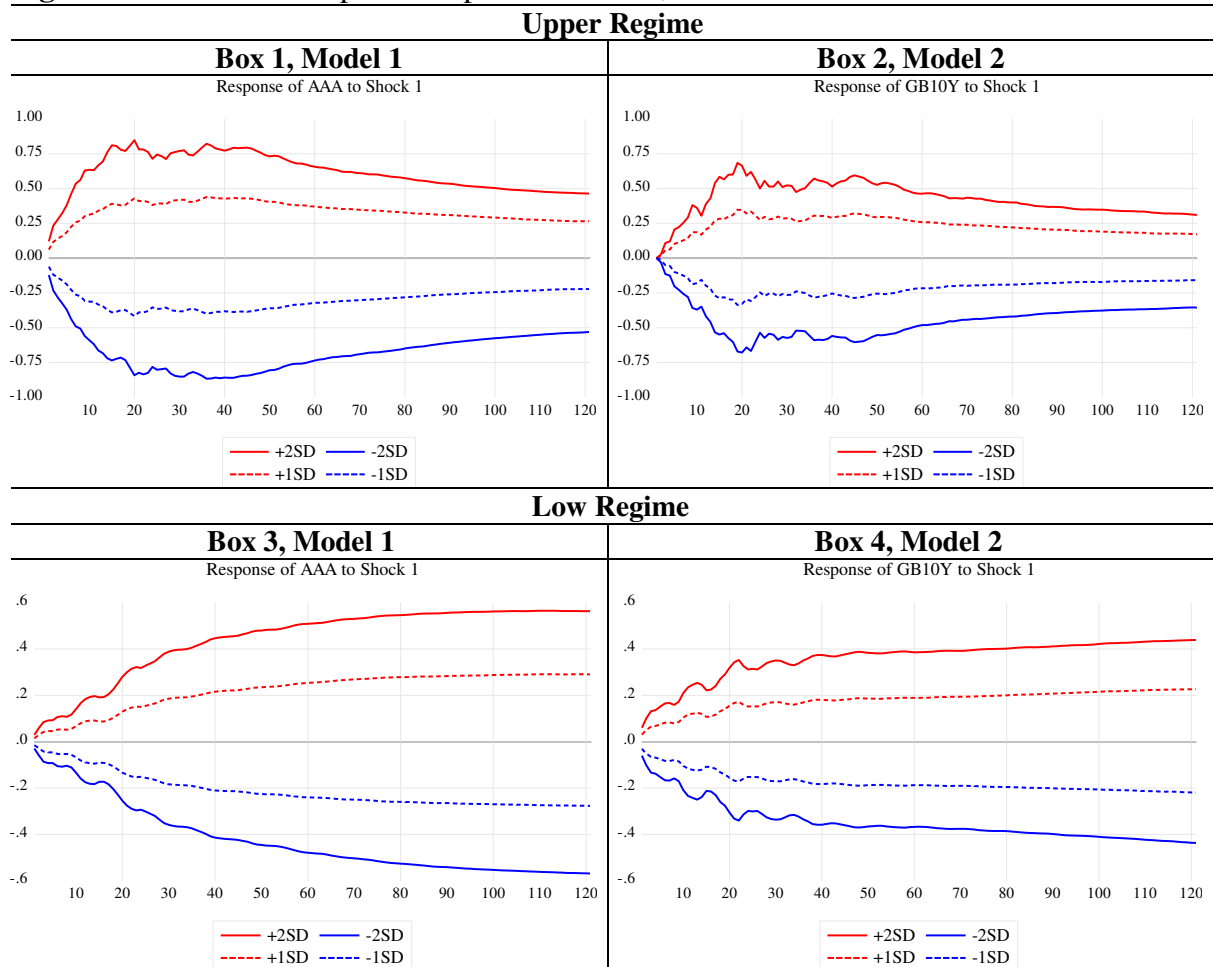
This section is dedicated to understanding the stability of our findings and whether a non-linear relationship exists between the considered variables.

First, we reported in *Appendix 4* the IRFs estimated on different time spans, namely from: (i) 1971:08 to 2018:06; (ii) 1954:07 to 1971:07 and from 1982:10 to 2018:06; (iii) 1954:07 to 1982:11 and from 1993:07 to 2018:06; (iv) 1954:07 to 1993:08 and from 2008:09 to 2018:06. Findings presented in *Appendix 4* confirm our previous estimations by allowing us to conclude that the results are robust to different model specifications. Specifically, in the case of *Model 1*, we can confirm a unidirectional influence that moves from a short- to long-term interest rate *AAA*. On the contrary, in the case of *Model 2*, we corroborate a bidirectional relationship when the 10-year treasury bond is introduced in the model as a long-term interest rate. In particular, a positive shock to *GB10Y* produces a positive and long-lasting effect on *FF*, usually significant up to eighty months after the initial shock. These results are confirmed in all the selected time spans reported in *Appendix 4*. Similarly, the effect generated by a positive shock to *FF* in *Models 1* and *2* is permanent and statistically significant over all the considered horizon of one hundred and twenty months. These results allow us to conclude that monetary

policy is able to permanently affect the level of the long-term interest rates not only in the short but also in the long term.

Second, to test potential non-linearity in our estimates, GIRFs through ThSVAR models are estimated. We are interested in understanding whether positive or negative changes in the short-term interest rate  $FF$  lead to a different reaction of the long-term rate  $AAA$  and  $GB10Y$ . Following Hansen's method of simulation (1996), the threshold value has to maximize the log determinants of the structural residuals and it is estimated on  $FF$ . In *Model 1*, the value of the threshold is about 7.18 and in *Model 2*, it is about 7.27. Upper regime GIRFs are estimated above these thresholds and in the case of values below the threshold, we calculate low regime GIRFs. Additionally, within each regime, we evaluate whether positive and negative shocks to  $FF$  produce symmetrical effects on long-term interest rates  $AAA$  (*Figure 5*, Box 1 and 3) and  $GB10Y$  (*Figure 5*, Box 2 and 4). Findings are reported in *Figure 5*.

**Figure 5.** Generalized Impulse Response Function, ThSVAR



In the upper regime (Box 1 and 2 in Figure 5), estimations produce similar hump-shaped GIRFs for *Models 1* and 2 with a peak effect that occurs by the fortieth month. The dynamics of the GIRFs are symmetrical both in the case of positive and negative shocks to  $FF$  thus showing a linear relationship between short- and long-term rates. Unlike the upper regime, in the low regime, the dynamics of the GIRFs are not hump-shaped (Box 3 and 4 in Figure 5). Indeed, the GIRFs reach a peak at a longer horizon where the response of long-term interest rates  $AAA$  and  $GB10Y$  stabilizes at a higher (or lower) level. As shown in Box 3 and 4, where the responses of low regime are considered, positive and negative shocks to  $FF$  determine symmetrical responses thus showing the existence of a linear relationship between short- and long-term interest rates even below the threshold. Yet, despite the presence of linearity in the relationship between short- and long-term interest rates within the same regime, such a linearity does not exist among regimes. Findings show that the peak effect reached in the upper regime is higher than the peak response effected in the low regime. However, the long-term effect, namely after one hundred months, is larger in the low regime than in the upper regime.

## 6. Conclusion

In order to detect the relationship between short- and long-term interest rates, the current paper focuses on data for the US economy for the 1954-2018 period. To do this, we implement a SVAR model on monthly interest rates, namely the federal funds rate, the 10-year treasury bond and the corporate bonds ranked AAA. We also check for robustness of the results using different model specifications.

Both the linearity in the relationship between short- and long-term interest rates within the same regime and the larger long-term effect in the low regime than in the upper one seem to confirm that central banks can affect long-term interest rates by changing the short-term rates. The lower effect estimated for the upper regime can be probably explained by stronger expectations of future falls in the short-term *nominal* interest rates over a certain threshold.

This result of a central bank that is able to affect long-term interest rates cannot be rejected on the basis of the bidirectional relationship found when the 10-year treasury bond is included as the long-run rate. Since a unidirectional relationship holds when the interest rate on corporate bonds ranked AAA is taken into consideration, the bidirectional relationship may simply reflect a sensitivity of central banks to public debt management. In addition, the estimated Forecast Error Variance Decomposition (FEVD) shows, on the one hand, that most



of the variability of long-term interest rates is explained by the short-run interest rate controlled by the Fed and, on the other, that  $FF$  is mainly determined by its own shock. The latter confirms that the central bank has a certain degree of freedom in setting the level of short-run interest rates.

Of course, this does not mean that monetary policy is set in a vacuum and that, in the short run, central banks may not lose control of the structure of interest rates. It only means that they have the power, when operating coherently, to affect this structure and, therefore, that there is a possibility that a monetary policy will affect income distribution. Since these results have been achieved considering a core country like the United States, further analyses, however, should be provided to assess to what extent international short- and long-term capital flows can limit the ability of monetary authorities to control the structure of interest rates – especially in small open countries.

In summary, our findings are in line with the Keynesian tradition and allow us to conclude that monetary policy is able to generate permanent effects on long-term interest rates over a long period of time. This confirms the idea that interest rates should be conceived as monetary-determined variables rather than be influenced by real factors such as “productivity and thrift”.

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## Appendix 1.

Effective Federal Funds Rate, Percent, Monthly, Not Seasonally Adjusted (FF)

Moody's Seasoned Aaa Corporate Bond Yield, Percent, Monthly, Not Seasonally Adjusted (AAA)

10-Year Treasury Constant Maturity Rate, Percent, Monthly, Not Seasonally Adjusted (GB10Y)

## Appendix 2.

These two subparagraphs contain the results of the unit root test (Phillips-Perron).

**2.1.** Effective Federal Funds Rate (FF), Moody's Seasoned Aaa Corporate Bond (AAA), and 10-Year Treasury Constant Maturity Rate (GB10Y)

**2.1.1.** Unit root test (Phillips-Perron):

**H<sub>0</sub>:** variable at level has a unit root.

Phillips-Perron Test						
Variables	Intercept		Trend & Intercept		None	
	Adj. t-statistic	P-value	Adj. t-statistic	P-value	Adj. t-statistic	P-value
FF	-2.362220	0.1530	-2.669383	0.2498	-1.355568	0.1627
AAA	-1.558726	0.5033	-1.564578	0.8061	-0.429502	0.5281
GB10Y	-1.609921	0.4770	-1.875761	0.6661	-0.614086	0.4513

**2.1.2.** Unit root test (Phillips-Perron):

**H<sub>0</sub>:** variable at first difference has a unit root.

Phillips-Perron Test						
Variables	Intercept		Trend & Intercept		None	
	Adj. t-statistic	P-value	Adj. t-statistic	P-value	Adj. t-statistic	P-value
D(FF)	-18.68188	0.0000	-18.65883	0.0000	-18.69598	0.0000
D(AAA)	-19.49090	0.0000	-19.52537	0.0000	-19.50426	0.0000
D(GB10Y)	-20.62701	0.0000	-20.65691	0.0000	-20.64122	0.0000

### Appendix 3.

This appendix contains the results of the lag length selection based on the Akaike Information Criterion

Akaike Information Criterion		
Lag	Model 1	Model 2
0	8.837636	8.604051
1	0.976063	1.433349
2	0.704850	1.146586
3	0.641187	1.107962
4	0.647169	1.101968
5	0.646653	1.093609
6	0.651515	1.088153
7	0.617316	1.077898
8	0.620729	1.069951
9	0.549445	1.001671
10	0.544598	0.989285
11	0.546540	0.989867
12	0.546526	0.992237
13	0.520501	0.960638
14	0.500539	0.946478
15	0.494635	0.938184
16	0.467265	0.909867
17	0.440806	0.887651
18	0.447033	0.893524
19	0.417085	0.873333
20	0.419544	0.864878
21	0.403991	0.861040
22	0.408076	0.855026
23	0.398092	0.837200*
24	0.398785	0.843327
25	0.395010*	0.846523
26	0.404128	0.855253
27	0.400868	0.844849
28	0.395485	0.838803
29	0.404512	0.848049
30	0.409417	0.854265
31	0.418802	0.860829
32	0.424342	0.868201
33	0.432614	0.874307
34	0.432326	0.871321
35	0.438127	0.877614
36	0.441600	0.882929



## Appendix 4.

IRFs estimated for selected sub-samples for Models 1 and 2 are shown in the following figure.

### Impulse Response Function, selected sub-samples for Models 1 and 2

